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Tick-Borne Diseases and How to Prevent Them

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I. Importance of Tick-Borne Diseases in the U.S.

A. Worldwide, the mosquito is the number-one arthropod vector of human disease, e.g. up to 500 million people contract or die of malaria alone throughout the world every year.

B. Narrowing the geographic focus to North America, or the United States, ticks are the major vector for arthropod-borne diseases of humans, and LD is not the only illness they transmit: There are approximately 10 tick-borne diseases of concern in the U.S.:

1. Lead in prevalence by LD. In 1998, the Centers for Disease Control and Prevention (CDC) reported 16,801 cases of LD.

2. Followed by RMSF, which unlike its name would suggest, is MOST prevalent in the eastern part of the U.S., not the Rocky Mountains. It was first discovered and studied in a Rocky Mountain state (Montana), and it is from that area that it's name is derived. Routinely, the highest numbers of cases are reported from NC. In 1998, there were 365 cases of RMSF reported for the U.S.

3. More recently recognized diseases include 2 different types of human ehrlichiosis: human monocytic ehrlichiosis (HME) and human granulocytic ehrlichiosis (HGE), the main differences being: 1) different types of white blood cells are infected (granulocytes in the case of HGE, and monocytes in the case of HME); 2) they are caused by 2 different, although closely-related, organisms; and 3) they are transmitted by 2 different species of tick.

4. Babesiosis is a malaria-like illness and may be fairly prevalent in the areas where LD is prevalent.

5. Relapsing fever, Colorado tick fever, tularemia, Powassan encephalitis, and tick paralysis are less prevalent.

6. All of these tick-borne diseases are caused by microorganisms with the exception of tick paralysis, which is caused by a neurotoxic chemical that is secreted by the tick in its saliva as it feeds, causing an ascending paralysis that can eventually lead to death. Fortunately, if the tick is discovered and removed, symptoms usually resolve quickly and completely.

7. Only four of these tick-borne diseases are nationally reportable: LD, RMSF, HME, and HGE. RMSF has been reportable for many decades; LD since 1991; and most recently, HME and HGE since 1999. Therefore, our knowledge of the incidence of the others is more anecdotal.

B. Different species of ticks transmit different diseases (or groups of diseases). There are 3 tick species that you are most likely to find associated with human tick bites and disease: the black-legged tick (more commonly known as the deer tick), the lone star tick, and the American dog tick.

1. The black-legged tick (*Ixodes scapularis*) is the major vector for LD, HGE, and babesiosis. The highest concentrations of these diseases are in the northeastern and mid-Atlantic seaboard states, and in the upper Midwest (WI and MI), not surprisingly, areas where the black-legged tick is the most prevalent. The vector for these diseases along the Pacific coast is a closely related tick known as the western black-legged tick (*I. pacificus*), but it looks the same. A single black-legged tick can be coinfected with 2 or even all 3 of these disease organisms, and therefore has the potential to transmit more than one infection simultaneously.

2. The lone star tick (*Amblyomma americanum*) is the vector for the monocytic form of human ehrlichiosis (HME), which is most prevalent in the southeastern and south central states. It may also be responsible for transmitting a disease similar to LD (Lyme-like illness), which is currently one of the areas of much medical and entomological controversy and investigation.

3. The American dog tick (*Dermacentor variabilis*) is the major vector for RMSF, most prevalent in the southeastern quadrant of the U.S.

II. Lyme disease.

A. History. LD was first recognized in 1975 following an outbreak of cases in Lyme, CT. It is caused by a spiral-shaped bacterium, or spirochete, known as *Borrelia burgdorferi*. The pathogen can cause a wide range of symptoms, which can sometimes become debilitating, but are usually not fatal. The spirochetes are found in the mid-gut of the tick, and once the tick begins to feed on a host the spirochetes begin to multiply, travel to the salivary glands, and flow with the tick's saliva into the bite site. It usually takes at least 24 hours, or longer, for an infected tick to transmit infection to the host. Ticks densities, as well as infection rates in tick populations, are very focal, and can vary greatly from county to county and even within individual counties.

B. Symptoms.

1. One of the most common early symptoms is a red, ring-like rash called erythema migrans, which occurs at the site of the tick bite, and expands, frequently to at least several inches in diameter. It generally clears in the center and has a reddened border. It develops as spirochetes disseminate locally in the skin. Other very common early symptoms are flu-like: fever, headache, muscular & joint aches and pains, and extreme fatigue. The rash and/or other early symptoms appear within 3 days to 1 month following a tick bite. Up to 40% of patients do not exhibit the rash at all.

2. As the disease progresses, multiple secondary EM lesions can appear on other parts of the body. Episodes of joint pain increase in frequency and duration. The nervous and cardiac systems become affected. A common early neurological symptom is Bell's palsy (a paralysis of one side of the face). Difficulties with memory, concentration, and equilibrium may be experienced. Heart symptoms include dizziness, weakness and an irregular heartbeat.

3. Long-term effects and permanent damage can include debilitating arthritis and severe neurological deficits.

4. The disease can be treated with oral antibiotics (doxycycline or amoxicillin), but it is more easily cleared up the sooner it is treated. Once the disease has progressed, intravenous antibiotic therapy may be required, and even then, symptoms may linger indefinitely. NOT all ticks are infected, so in most cases it is not a good idea to get antibiotics solely for a tick bite with no symptoms.

5. Of the other tick-borne diseases, the only one that also has a hallmark rash associated with it is RMSF (red spotted rash that starts on the extremities and quickly covers most of the body; up to 20% may not experience a rash). Other symptoms of RMSF are flu-like, including high fever, severe headache and nausea/vomiting. It is a disease that progresses quickly -- you get very sick fast. LD is not considered a fatal disease, although it can be extremely debilitating; RMSF, as well as most of the other tick-borne diseases, can be fatal.

D. Life cycle/Animal Hosts.

1. The black-legged tick, like all hard ticks, goes through 4 developmental stages: egg, larva, nymph, and adult.

2. The black-legged tick is a 3-host tick: requires a blood meal on a different host at each of the 3 active stages, as a larva and as a nymph in order to grow and molt to the next life stage, and as an adult in order to mate and produce eggs. In other words, it needs 3 hosts and 3 blood meals in order to complete its life cycle. Generally, the male feeds very little if at all. So even if a male tick is infected, there is little chance it can pass on infection to a host because it does not stay attached to feed for a long enough period of time.

a. In the spring, the female lays an egg mass of 2-3 thousand eggs in the leaf litter. The eggs hatch into tiny, 6-legged larvae, in the summer (July through September), and they remain at ground level in the leaf litter or similar low-lying debris with their front pair of legs extended, waiting for a host to pass by (this is called questing behavior). They latch onto passing hosts, usually small rodents such as the white-footed mouse, which spend a good deal of their time foraging around in the leaf litter.

b. The larvae feed for 2-3 days, then drop off the host, and overwinter in the protection of leaf litter until the following spring, at which time they molt into nymphs that have 8 legs. A year has now gone by. The nymphs quest during the spring (May-June) and attach to hosts, again small rodents. If a nymph fed on an infected mouse as a larva, it retains the spirochetes through the molt (called transtaadial passage) to become an infected nymph that can then pass on the infection when it feeds on an uninfected host. The white-footed mouse is the most significant >reservoir host= meaning that the spirochetes circulate in the blood of the mouse making it possible for feeding ticks to pick them up. *B. burgdorferi* is maintained in the environment because mice infect ticks, and ticks infect mice, and the vicious cycle continues.

c. Nymphs feed for 3-4 days, drop off the host, and molt to adults (male and female) in the fall. Adults quest on vegetation such as high grass, weeds, and the shrub layer of wooded areas. In this way they most frequently come into contact with larger mammals. Deer are the primary host of adult black-legged ticks, although many animal species are attacked. Black-legged ticks are most prevalent where deer are present. Adult female ticks feed for approx. 1 week, mate, and drop off the host. The following spring, they deposit their eggs, and die, completing the 2-year life cycle.

E. Habitat. The ticks survive best in moist areas that are protected from intense sunlight so that they don't desiccate. This includes woods and woodland edges, leaf litter, high grass, weeds, shrubby undergrowth. These are the same areas that are preferred by mice and other rodents, because they can easily hide, nest, and forage for food. The adult host of the ticks, primarily deer, also inhabit woods, woodland edges, and shrubby areas because of the protective cover and abundant browse. Ticks are less likely to be found in well-mown and manicured expanses of lawn. Within suburban residential settings in the Northeast, one study* revealed 89% of the deer ticks were collected from adjacent woods and woodland edges; 9% from ornamental plantings; and 2% from maintained lawns (if animals traverse the lawn, ticks riding on their fur can drop off).

III. How to Prevent Lyme Disease.

A. Customer Relations. An enthusiastic personality, good communication skills, and professional manner, are important; otherwise, regardless of how well you know the subject, you may not give that impression. Unfortunately, completely ridding a property of ticks, especially for the long-term, is not feasible. Many factors are at play, and an integrated control approach will be necessary, not the least of which will be for the homeowner to buy into the inevitability and importance of employing personal protective techniques. You will need to educate and convince the homeowner of this integrated approach.

B. Personal Protective Techniques: Applies to technician as well as homeowner.

1. Avoidance. Do not enter areas of tick habitat. Stick to the middle of trails when hiking, etc.

2. Protective Clothing:

a. Wear light-colored clothing - you can more easily spot dark-colored ticks.
b. Cover as much skin as possible: long pants, long sleeves
c. Prevent access of ticks through openings in clothing by tucking pants cuffs into socks or boots; tucking shirt into pants. Larval ticks can fit through the weave of most socks, so either use high top shoes or boots, or lightly spray outside of socks with permethrin repellent.

3. Routine tick checks/tick removal. Check clothing and exposed skin routinely when in tick habitat. Check your clothing carefully before you return indoors or get back into your vehicle, so that ticks don't drop off inside. Remove clothing when you return indoors and carefully check your whole body. You may detect attached ticks during a shower. Placing clothing in a hot dryer for 20-30 minutes will kill any ticks you may have missed. Remove any ticks attached to your skin properly.

a. Use fine-tipped tweezers.

b. Pull firmly opposite the direction in which the barbed, needle-like mouthpart known as the hypostome is inserted in the skin (as you would for a splinter).

c. Do not squeeze the body of the tick, or place substances (such as nail polisher, nail polish remover, lighted match, etc.) on the tick while it is attached because this might agitate the tick and cause it to regurgitate infective fluid into the skin.

d. It usually takes 24-48 hours for an infected black-legged tick to effectively transmit the Lyme disease pathogen, so the sooner you remove a tick, the safer you'll be.

4. Pet inspection/grooming. Carefully inspect pets that spend time outdoors. Pets can get Lyme disease, and they can carry ticks into the house. If the ticks are still clinging to the surface of the fur, they can easily drop off and crawl onto someone else. Female ticks that are allowed to fully engorge on a pet may drop off and lay their eggs inside (in a sofa for example). This will cause an indoor infestation of larval ticks.

5. Personal repellents.

a. Repellents containing **deet** can be used on exposed skin [e.g. 3M Ultrathon® Insect Repellent (the best because it contains only 33% deet yet lasts for up to 12 hours; it is the same as the military formulation)]. Deet is excellent against mosquitoes, but is less effective against ticks. A concentration greater than 40% is UNNECESSARY because higher concentrations are no more effective.

b. Repellents containing **permethrin** (e.g. Repel Permanone®, Duranon® Tick Repellent; these products contain 0.5% permethrin and are the same as the military aerosol formulation) can be used on clothing, and **work best against ticks.** Permethrin bonds so strongly to clothing that it remains effective through a number launderings. Permethrin is highly toxic to ticks, and as soon as they come into contact with treated fabric, they absorb enough of the chemical to become intoxicated. Permethrin has low mammalian toxicity. It is very safe and very effective for human use when used according to label instructions.

C. Vaccines.

1. A canine LD vaccine has been in use for about a decade.

2. In December 1998, the first human LD vaccine (**LYMErix®)** was licensed by the Food and Drug Administration (FDA). It currently remains the only human LD vaccine available.

a. Developed by SmithKline Beecham (now GlaxoSmithKline).
b. For use in individuals aged 15 to 70 years.
c. Requires 3 inoculations at a set schedule over the period of a year: initial, 1 month, and 12 months.
d. After the 2nd inoculation at 1 month the vaccine is approx. 50% effective, and after the 3rd inoculation at 12 months the effectiveness is 78%.
e. The vaccine consists of one of the proteins found on the outer surface of *B.*

burgdorferi (outer surface protein A, or OspA). Following vaccination, the body produces antibodies directed against OspA. When an infected tick feeds on the blood of a vaccinated individual, the antibodies in the blood attack the spirochetes in the gut of the tick, killing them before they can be passed into the person.

f. The frequency and safety of boosters has not yet been determined.
g. LYMErix will not protect against any other tick-borne illness, nor is it effective against strains of the LD pathogen found outside North America.
h. Some questions over safety of the vaccine have recently been raised based on hampster studies and a class action lawsuit against SKB [i.e. ability of the vaccine to trigger a chronic form of arthritis in genetically predisposed individuals (HLA-DR4)?]

D. Environmental Modification. Reduce tick habitat and rodent harborage. Do this by:

1. Keep lawn well-mowed.
2. Clear undergrowth and leaf litter to as far from the house as possible.
3. Keep woodpiles, bird feeders, and other rodent harborage and food as from the house as possible.
4. If deer are a problem, consider planting shrubs/trees t hat are less appetizing to deer. Lists of such plants are often available from extension agents. Remove shrubby undergrowth from wooded areas to reduce browse.

E. Surveillance. It is prudent to survey areas for the presence and abundance of black-legged ticks before implementing an intensive tick management program, especially before applying pesticides. The presence of tick habitat is not a guarantee that ticks will necessarily be present.

1. Tick drags, or flags, or walks (wearing white coveralls). These methods give the best indication of current questing tick loads that an individual or pet might encounter. Flagging is perhaps the most productive, because you can sweep the cloth over the vegetation as well as poke it down into denser undergrowth and leaf litter. The best fabric to use for a flag/drag is one that has a lot of nap (ticks cannot grasp tightly woven, slick material). Brushed corduroy or flannel is best (crib sheeting that is flannel on one side and rubberized on the other is best because it is durable). The fabric should be white.

2. Other methods are either more time-consuming and manpower intensive, or don't give as direct an idea of what current questing tick loads are: small mammal trapping, CO^2 traps.
3. Perform surveillance at the appropriate time of year:

a. Adults: Fall, warm winter spells, early spring.
b. Nymphs: May or June
c. Larvae: July or August

4. Perform dragging/flagging surveillance at the appropriate time of day:

a. Larvae and nymphs (Spring/summer): Cooler parts of the day, typically mid-morning after the dew has dried.

b. Adults (Fall, early spring): Warmest parts of the day, typically midday.

c. These surveillance techniques are not effective when the vegetation or leaf litter is wet.

d. If surveys will be repeated, standardize by collecting at the same time of day/under similar ambient conditions/using the same collection distance or period of time.

F. Pesticide application.

1. Unconventional: host-targeted.

a. Targets immature ticks on mice: Biodegradable cardboard tubes containing permethrin treated cotton that mice will use as nesting material. Permethrin kills immature ticks on the mice. Studies have shown that while the method is scientifically and environmentally sound, the results in actually controlling questing ticks is unpredictable, and may have only limited utility as part of an integrated control program. Studies have also been conducted with tubes containing pesticide-coated strips and a bait. Mice self-treat themselves with pesticide when entering the tubes to retrieve the bait. Aventis is currently testing tubes that contain fipronel treated strips.

b. Targets adult ticks on deer: The FDA is testing deer-feeding stations known as the 'four-poster.' A hopper holds corn as a bait, and when a deer comes to feed, it must push its head through 'paint rollers' that are saturated with an acaracide, thus self-coating their head and neck in the process.

2. Conventional: habitat-targeted. Liquid formulations are aimed at questing ticks (i.e. nymphs in the spring; larvae in the summer; adults in the fall.) Granular formulations will penetrate leaf litter better to reach nymphs overwintering in the fall; or larvae as they hatch from eggs in the early summer. High-pressure sprayers may disturb the leaf litter enough to reach larvae and nymphs in the leaf litter. Pesticides are generally very effective in controlling the stage of tick they are aimed at; however, reducing the number of one stage by controlling the previous one will be limited in a small area (most residential sites) because of constant reintroduction of ticks into the treatment area from untreated sites via mammal hosts.

IV. WRAP-UP.

A. Three factors influence getting the tick control/Lyme disease prevention job done right:

1. Knowledge: You must know the tick and its ecology in your area. This comes from such sources as experience, colleagues, extension agents, scientific literature, local universities, etc.

2. Interpersonal communication skills and integrity: This factor allows you to develop rapport with your customer and gives you the ability to effectively transfer your knowledge. This, in turn, builds understanding, trust, and success, because the homeowner participates in maintaining optimum tick control and protecting himself.

3. Technical skill: Good surveillance techniques are important to accurately delineate the situation so that you can choose the best integrated control techniques, including appropriate acaricide applications.

B. All these factors (knowledge, communication, and skill) results in successful business (jobs done well, satisfied customers, fewer call-backs).

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® LYMErix is a registered trademark of SmithKline Beecham Biologicals S.A., Rue de l'Institut, 89 B-1330, Rixensart, Belgium

Some references of interest.

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* Dennis, D.T., T.S. Nekomoto, J.C. Victor, W.S. Paul & J. Piesman. 1998. Reported Distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. J. Med. Entomol. 35(5):629-638.

Lyme Disease: Assessment and Management of Vector Tick Populations in New Jersey, T. Schulze, L. Vasvary & R. Jordan, NJ Health Dept/Rutgers Extension Bulletin #E180.

Ecology and Environmental Management of Lyme Disease, H. Ginsberg, ed., Rutgers Press. 1993.

Resistance of Ornamentals to Deer Damage, Fact Sheet 655, Cooperative Extension Service, University of Maryland.

Controlling Deer Damage in Maryland, Extension Bulletin 354, Coop. Ext. Svc, U. of Maryland.

Useful websites.

www.cdc.gov	Centers for Disease Control and Prevention
www.lymediseaseinformation.com	Pfizer Lyme Disease and Related Disorders Pamphlet
www.riaes.org	Rhode Island Agricultural Experiment Station
www.state.ct.us/caes/FactSheetFiles/IndexHeadingFiles/Fstick.htm	Connecticut Agricultural Experiment Station Fact Sheets
www.ent.iastate.edu	Iowa State University of Science & Technology, Dept. of Entomology
www.imugen.com	Imugen, Inc.
www.lyme.org	Lyme Disease Foundation, Inc.
www.aldf.com	American Lyme Disease Foundation, Inc.
www.lymenet.org	Lyme Disease Network of New Jersey
www.afpmb.org	Armed Forces Pest Management Board
chppm-www.apgea.army.mil/ento	U.S. Army Center for Health Promotion & Preventive Medicine, Entomological Sciences Program